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RURAL ELECTRIFICATION IN WESTERN AUSTRALIA

A brief Review of the Development of a Rural Electrification Programme in the South-West Land Division Area of Western Australia

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1. INTRODUCTION

As we celebrate the Bicentenary of the arrival of Captain Cook in Botany Bay, there will no doubt be many books and articles written to record Australia's development over the last two hundred years.

These histories will certainly include a number relating to the accomplishments of engineers and engineering organisations.

Some of the great projects that come to mind would include the water pipeline to Kalgoorlie, Sydney Harbour Bridge, the Snowy Mountain Hydro Electric Scheme and the Trans Australian Railway to name but just a few.

Closer to home in Western Australia, and within the last four decades, we could list the construction and sealing of our Highway Road System, the Narrows Bridge, the powerline from Muja to Kalgoorlie, the mining developments in the Northwest and in the Goldfields and the North West Shelf Gas Project.

All of these and many others were great projects, involving large capital expenditures over relatively short periods of time and requiring engineers to solve various new problems on a very large scale.

Most of these developments have been well documented at their time of construction and have been faithfully recorded in the history books for future reference.

However, I suggest that in a State as vast and isolated as Western Australia there are many other engineering projects which have been completed but which have not enjoyed a favourable front-page coverage by either the media or the historians. Included in these would be the development of the State's country road system, water network and power grid.

Maybe these works took longer to accomplish, did not require a large capital expenditure over a short period of time or did not produce a single edifice which could be viewed at close quarters. Never-the-less such projects have had a marked effect on both the economic and social development of the State.

For a few moments this evening, I would like us to consider just a small aspect of one of these projects, namely the State Electricity Commission's 200,000 square kilometre development of the Rural Electrification Programme to the farmers in the State's South-West Land Division.

2. SOUTH-WEST POWER SCHEME ACT

The genesis of such a programme is very hard to fix as would become obvious when reading J. de Burgh's report entitled "The Development of a State Government Electricity and Gas Supply in Western Australia".

Numerous groups of people, committees and politicians had reviewed the question over many years. Mr. J.M. Speed, a member of the Legislative Assembly for the Metropolitan Province is recorded in Hansard on 3rd October, 1901, as having moved:

> "That, in the opinion of this House, it is advisable that the Government should without delay, make enquiries as to the practicability of transmitting electricity power to the Goldfields from Collie by means of wire".

However, the actual date of conception of the legal authority to implement such a programme was the passing of the South-West Power Scheme Act in 1945.

This Act initially sanctioned the Commission to purchase the Collie Power Station of which it took control of as from midnight on October 11/12, 1946. The station was enlarged from 5MW to 12.5MW with the new section supplying 50 hertz power on August 5, 1951. From then on the South-West Grid commenced to link up various country towns as the interconnecting lines were built through the rural areas.

3. THE RURAL PROBLEM

In general the farming community operated with individual 32 volt Direct Current generating plants powered by small diesel engines. Banks of batteries were fitted to provide lighting at times when the diesel engines were not running.

It was not possible for them to run electric refrigerators which consequently were operated on kerosene and were quite a fire hazard.

Likewise, the diesel engine had to be running whilst the ironing was done.

32 volt equipment was costly to purchase, bulky to handle, with the diesel engines requiring constant maintenance and the battery banks regular replacement.

Electrically, the lot of the rural housewife was second rate when compared with her city or town cousin.

4. AMERICAN VISIT

Western Australia was not the first State to consider rural electrification programme. A number of the Eastern States had embarked on such works some years before; however, the leaders in such enterprises were indeed to be found in the United States of America.

So it was that Mr. J.B. Jukes, the Engineer South-West of the State Electricity Commission of Western Australia was sent to America to review the current practices of the day. On his return to Perth, he set about designing the rural programme to suit the local conditions.

Initially, the basic policy adopted by the Commission was to extend its electricity supply mains into areas where the revenue from the sale of electricity would justify the capital cost of the extension.

5. THE DESIGN

Due to the generally high resistance of the sandy soils in the populated part of the State, a "multiple earthed neutral" distribution system was proposed.

The distribution voltages chosen, on economic grounds, were 22,000 volts for the closer settled areas and 33,000 volts for the sparser areas, giving 12,700 and 19,100 volt single phase spur lines.

The transformers were nominally of 5KVA and 10KVA capacity with $\pm 2\frac{1}{2}$ & 5% tappings giving a 250/500 volt single phase supply to the consumer. Individual motors up to 2HP were allowed to be connected on 250 volts with the larger motors up to 10HP being connected across 500 volts.

The high voltage phase and earth wires were 7/16SWG galvanised 40/50 ton quality steel wire, which when attached to 35 foot poles gave a level ground span of about 600 feet. Later on, in the more sparsely populated areas, a 3/12 SWG 90/100 ton quality galvanised steel conductor was used giving a 100 foot level ground span on 35 foot poles. Every pole was numbered for identification purposes.

The design incorporated the requirement that both three phase and single phase lines were able to have maintenance carried out whilst the lines were kept alive. This included the changing of insulators, crossarms and poles - all carried out without shutting down the supply.

The High and Low voltage neutral points were bonded together at each transformer and connected to a driven galvanised steel earth electrode. On top of this, the high Voltage neutral/earth wire was also bonded to a similar earth electrode.

In general, the three phase backbone spurs were constructed with three phase wires mounted on an open-delta construction with 3 foot spacing and the neutral/ earth wire attached to small insulators mounted on the pole 4 feet below the centre phase wire. The open delta configuration allowed for easier and safer live line maintenance work to be carried out.

The point of attachment and metering point was selected so that the consumer did not have to run his mains more that 440 yards in any one direction. Where possible, this point was located near the load centre of the consumers installation.

Because metering points could often be quite some distance from the house or roadway - the meter reading was carried out by the customer, who was sent a card on which was printed a picture of the meter face. The customer then marked the card with the position of the register pointers and returned the card to the Commission for calculation of the reading, after which an account was issued. Periodically, a check reading was carried out by Commission staff.

The voltage on the 22,000 volt and 33,000 volt distribution feeders was controlled by automatic on-load tap-changing transformers at the major zone substations, with the busbars operating approximately 10% High at times of full load and dropping to about 3% High at times of light load. With these controlled variations it was possible to keep the voltage at the consumers metering point within the ±6% tolerance.

6. THE FIRST CUSTOMER

A Rural Consumer was defined as one who used power freely in the operation of his farmer practice. No differentiation was made between a dairy farmer who milked 20 cows and one who milked 80 cows or one who had a small water pump for irrigation or a fruit grader.

However a farmer who only wanted power for the house was classified as a Rural Domestic consumer; five of which equated to one Rural Consumer.

The first Rural Consumer was connected late in 1951. It was the dairy of Mr. Harold Johnston who farmed alongside the South-West Highway between Picton Junction and Dardanup. Initially he kept his standby diesel in case of a power breakdown but within twelve months he disposed of the engine as the number and duration of the power failures did not justify this precaution. Instead he arranged his vacuum pump so that it could be driven from his tractor.

7. STAGE ONE

Obviously, the start of this programme over such a vast area would attract a very large number of enquiries and requests for early connection. Many farmers had lighting plants that had given long service and were now in need of replacement - especially the banks of 32 volt batteries.

In order to provide an organised and yet fair approach to this problem, a policy was adopted whereby the 22,000 volt lines that radiated from the Zone Substation at Picton Junction, Bridgetown (Yornup), Albany, Collie and Northam were taken as the start points.

Farmers who were located within one quarter of a mile on either side of the radial 22,000 Volt lines were connected systematically and progressively starting from the Zone Substations. A second run was then made to connect those within half a mile of the line, then three quarters of a mile and so on.

In the more densely populated areas, as long as the farmers could be connected at the rate of no more than a quarter of a mile of single phase line per consumer, then spurs of up to two miles long were built.

When these areas had been covered, the length of line per rural consumer was extended to one third of a spur mile and finally to one half mile of spur line per connection.

8. THE SECOND STAGE

By 1959 it was found that the average revenue per connection did not justify extensions beyond half a mile per customer. However the number of rural consumers still to be connected was very large indeed.

To overcome this, the Commission's Act was amended and the Contributory Extension Scheme was introduced whereby the customers financed those lines in excess of half a mile per connection.

Basically, the Commission continued to provide the capital expenditure which could reasonably be expected to be returned by the revenue received, over the life of the assets involved. Capital funds in excess of this were financed by the consumer, together with an annual charge to cover the administration, maintenance and depreciation costs of the extension. All power consumed was charged at the standard electricity tariffs.

The cost of the additional extension beyond that which the Commission financed was called the Base Capital Cost (BCC).

The arrangement was based on a time scale of 30 years and the applicant had the opportunity to select one of three alternative methods of payment.

1. An annual payment of 12% of the BCC (to cover capital charges, maintenance, depreciation and administration charges) plus electricity at standard tariffs.

   or

2. A single capital contribution equal to the full BCC plus 6½% of the BCC per year plus electricity at standard tariffs.

   or

3. A single capital contribution to completely eliminate the annual charge component plus electricity at the standard rates. This contribution was 2.18 times the BCC based on the then normal interest rate of 5½% p.a.

The amendment to the Act made the annual payment under methods 1 and 2 a charge on the land which was arranged by lodging a caveat on the land to protect other persons with an interest in the land as well as the Commission.

The caveat could be lifted and the capital contribution refunded without interest when:-

1. The thirty year period had elapsed.
2. Additional consumers were connected which generated sufficient revenue to bring the scheme into line with the Commission's normal policy.

In 1966 the annual payment method was discontinued leaving only the other two methods open to the customer. This change allowed the requirement for the caveat on the land to be removed.

When additional consumers became connected to existing spurs, they would have to pay their share and in some cases the existing customers could receive a refund of capital or a reduced annual charge.

Initially the 'spurs' were relatively short in length and each 'spur' was protected by a single-shot high voltage drop-out expulsion fuse at the point where it left the 'main-line'. Individual rural transformers on each spur were not fused on the high voltage side but were fitted low voltage fuses to protect them from overload.

However, as the spurs became longer, it became necessary to consider a method of protection that would enable faults that occurred towards the end of the spurs to be isolated from the rest of the network.

The characteristics of the thermal fuse elements did not give much discrimination when a number of fuses were connected in series, even though they may have had substantially graded ratings.

To solve the problem, two and three-shot fuses were installed, which, with graded thermal ratings gave the necessary performance results.

Never-the-less, as so many faults on such a network are of a transient nature, the blowing of these expulsion fuses would leave quite a number of consumers without power for a long period of time until the faultman could be called out and travel to the fuse location. In some cases, this could involve a round trip of up to 300Km - excluding the time to locate the actual fault.

A further development was the fitting of automatic reclosers which would overcome the transient fault problem - but these were considerably more expensive than the expulsion fuses.

The HV drop-out fuses had one very unfortunate characteristic in that when they operated, they ejected towards the ground a minute amount of high temperature metal. In certain weather conditions and where the fuse pole was surrounded with dried grass or leaves, it was possible for a ground fire to start.

To overcome this feature, manufacturers were encouraged to produce fuse elements that contained the hot metal pieces or caught them in some form of basket at the fuse. The only really sure method that was adopted was to limit the growth of fresh vegetation around the base of the fuse poles by spraying with various herbicides - a very costly exercise.

9. THE VERY LONG SPURS

It is a well known fact that an AC charged insulated wire running parallel to the ground will have a capacitance effect. If the length of line is considerable, then this effect will result in a rise in voltage along the line, which at times of light load, can be of quite some magnitude.

When the line is loaded, this capacitance affect is very useful in overcoming some of the reactance drop caused by heavy motor loads.

In the case of the very long lightly loaded spurs that were built it became necessary to fit 'reactors' at selected points to reduce the voltage rise and to keep it within the legal ±6% tolerance. This unusual feature is not often experienced in power systems throughout the world.

10. GROWTH

From the very small beginning in 1951 in Dardanup, the number of connections grew progressively each year.

By 1978, some 17,000 rural consumers had been connected bringing an electricity supply to almost 90% of the rural consumers in the area.

Construction was maintained at a rate that connected over 1,200 new customers per year.

The average cost per customer to the Commission had risen to $3000 whereas the average cost to the customer was up to $2000.

By June 1987, the number of rural consumers had risen to over 26,000. All the major farming areas in the South-West Land Division had now become connected to the rural network. The programme was complete with only a few very small pockets to be connected.

The task ahead is to maintain the investment.

11. CONCLUSION

As we enter the third century of white settlement in Australia, we, in, Western Australia, as in the other States, can be proud of having provided a reliable electricity supply to the farmer and other residents throughout the whole of the South-West Land Division of the State.

Careful engineering planning in the initial stages, followed by constant reviews of costs, materials used and methods of construction have enabled the work to be completed in a planned and economic manner.

The country folk are no longer the 'poor cousins' of their urban brethren from the electrical viewpoint. The Country and Metropolitan tariffs were equated in 1975.

I suggest that the engineering expertise that has brought the programme to completion in 35 years has been one of Australias best kept secrets.

Surely, we should consider exporting our knowledge and experience to provide similar facilities and resources to the third world countries of our planet.

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